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Do perceptions about the COVID-19 pandemic vary by gun ownership? A study of Texas adults

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DECLARATIONS:

Ethics approval and consent to participate The University of Texas at Tyler Institutional Review Board approved data collection for this study, which is stated in the manuscript.

Consent for publication Not applicable

Patient & Public Involvement This study did not include patients from any clinical settings. Participants were adult residents on Texas.

Availability of data and materials The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests The authors declare that they have no competing interests.

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Authors' contributions RM Johnson and M Owens conceived of the paper and developed survey items. M Owens secured funding and conducted data collection. RM Johnson, M Owens, and EMA Goodell worked together to plan and conduct data analysis. A Wisniowski and JW Sakshaug conducted sensitivity analyses. C Crifasi, M Owens, and RM Johnson drafted the full manuscript, with substantive input from all authors.

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Article Summary

- In the US, gun sales increase during times of crisis or uncertainty, and they have increased during the COVID-19 pandemic.
- Despite an apparent connection between views favoring individual gun rights and opposing restrictions to prevent the spread of COVID-19, the perceived importance of taking precautions to prevent transmission was equally high among Texas adults with versus without household guns.
- A sizable proportion of Texas adults purchased or considered purchasing guns or ammunition in the early stage of the COVID-19 pandemic.
- *Strengths & Limitations:* A strength of this study is that we rapidly collected data on gun-related behaviors in the beginning of the COVID pandemic. Because non-probability samples are subject to bias, we conducted state-of-the-science strategies to quantify sampling bias. Findings cannot be generalized beyond the state of Texas.

ABSTRACT

Objectives. To investigate gun carrying, recent purchases of guns and ammunition, and associations between gun ownership and beliefs about COVID-19 among Texas adults in the early stage of the pandemic. We considered the perceived likelihood that the pandemic would lead to civil unrest, the perceived importance of taking precautions to prevent transmission, and perceptions that the threat of COVID-19 has been exaggerated.

Methods. We surveyed Texas adults from April 5-12, 2020, after the statewide stay-at-home declaration (*n*=1,183). We conducted multiple regression models to estimate differences in beliefs in association with household gun ownership, adjusting race/ethnicity, sex, rural residence, and age category.

Results. Fifteen percent of Texas adults reported a past-week gun purchase, 20% purchased ammunition, and one-fourth carried a gun most of the time when away from home. Comparing those with versus without household guns, we found little support that there were differences in the perceived importance of taking precautions to prevent the spread of the virus or in the perceived likelihood of civil unrest. Texas adults with guns were ~20% more likely those without them to believe the threat of COVID-19 was exaggerated.

Conclusions. Compared to those without guns, gun owners may be equally as likely to support taking precautions to prevent the spread of COVID-19, but may be more likely to downplay the threat of COVID-19. The polarized discourse about COVID-19 may have led to confusion about its severity suggesting a need for messaging that avoid stirring up political identities.

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INTRODUCTION

In the US, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) first occurred in Washington State in March 2020. COVID-19, the disease caused by SARS-CoV-2, has since emerged as a public health catastrophe with more than a quarter-million deaths.[1] Given the highly-infectious nature of SARS-CoV-2, states began to enact stay-at-home orders to slow the spread in mid-March.[2] The public health response quickly became enmeshed in 'culture wars,' with groups staging protests in opposition to those orders.[3] Protesters expressed their view that COVID-19 was not a serious disease, no worse than the flu, and characterized stay-at-home orders and other measures to prevent transmission (e.g., closures of schools and restaurants) as federal overreach and a threat to freedom and liberty. News and social media have given the impression that there was substantial overlap in groups demonstrating against stay-at-home orders and those supporting individualistic interpretations of the Second Amendment. Some protestors openly carried firearms at demonstrations, further suggesting links between those who favor unrestricted rights to have and carry guns and those who oppose public health measures to control COVID-19.[4]

In this study, we sought to explore the overlap in perceptions about COVID-19 and gun ownership in Texas, a state where there was strong opposition to stay-at-home orders.[5,6] Texas is the largest state in the US and is a conservative-leaning state with a culture supportive of gun ownership and a history of independence from the federal government. The state established a stay-at-home order in April 2020, after many states across the US and nearly one-third of counties in Texas had already done so.[2,5] Shortly thereafter, there were protests at the Texas State Capitol with demands to reopen the government and calls for freedom from tyranny.[6,7]

Connections between support for individualistic interpretations of the Second Amendment and opposition to the public health response to COVID-19 may have roots in politics and industry practices. The National Rifle Association (NRA) and the firearm industry more broadly capitalized on the fear and uncertainty around COVID-19 to promote guns as necessary during the pandemic;[8] these efforts may have ramped up beliefs that there would be civil unrest. After several states classified gun dealers as non-essential businesses, the President of the United States ordered the firearm industry be classified as essential at the federal level, forcing states that had closed gun shops to allow them to operate.[9] This action bolstered support for the President and others in his political party from gun rights activists in an election year. There were dramatic increases in firearm sales as the COVID-19 pandemic emerged.[10] The number of monthly background checks conducted by the FBI, an indicator of gun purchases, reached an all-time high in June 2020,[11] and was 70% higher than the number from June 2019 (Figure).

In the US, and in Texas specifically, the COVID-19 pandemic was highly-politicized and became intertwined with conversative political ideologies, including ideas around individual gun rights. There are

many potential adverse outcomes related to politicizing the COVID-19 pandemic; people may downplay the severity of the disease and become less willing to take the recommend public health precautions or support public health mandates, people may buy guns and ammunition, and people may be more inclined to carry their guns around. Failure to take recommended precautions could lead to increased spread of SARS-CoV-2, whereas gun acquisitions and increased gun carrying may increase risk for firearm suicide, lethal assaults, and unintentional injuries.[10] Apparent connections between beliefs about gun rights and about perceptions of COVID-19 raises the possibility that people with guns may be less supportive of public health strategies to respond to the pandemic. To enhance what is known on this topic, we investigate: (1) differences in perceptions about COVID-19 among Texas adults with versus without guns, and (2) recent gun acquisitions, gun carrying, and purchases of ammunition among those with guns. We explore perceptions that the COVID-19 pandemic will lead to civil unrest, perceived importance of taking precautions to prevent transmission, and perceptions that the threat of COVID-19 has been exaggerated.

METHODS

Data for this cross-sectional study come from the Texas Mental Health Survey, which was a statewide sample of adult residents conducted from April 5-12, 2020. The IRB at University of Texas at Tyler approved data collection, and participants had no involvement in the planning or conduct of the study. Data collection began shortly after the statewide SAH order went into effect. SARS-CoV-2 infections and COVID-19 deaths in the state nearly doubled over the data collection period; reported infections increased from 7,276 to 14,624, fatalities increased from 140 to 318.[1,2] Eligible respondents were Texas residents, fluent in English or Spanish, and age 18 or older. The mixed-mode sample included 77 residents who were contacted by telephone using a random-digit-dial (RDD) sample and 1,120 residents who were randomly selected from a panel of adults in the state who opted-in to take surveys through Dynata, a survey research company. The online and telephone surveys were conducted in both English and Spanish. The response rate for RDD sample was 8% and the cooperation rate was 19%. [12] We restricted analysis to the 1,183 respondents who answered the item about household guns.

The main exposure variable was household gun ownership, assessed with the following question: "*Do you happen to have any guns or revolvers in your home, garage, or car?*". All respondents were asked about plans to acquire guns: "*Are you or is anyone in your household considering getting a gun for your home in the next 2 weeks?*". Respondents with a household gun were asked about: [a] the number of guns (i.e., "*How many guns are there in your home, garage, or car?*"; options were 1, 2, 3+, and 'not sure'); [b] personal gun ownership ("*Do any of the guns belong to you, personally?*"); [c] recent gun acquisitions ("*Were any of the guns in your home purchased or obtained within the last 7 days?*"); and [d]

recent ammunition purchases ("*In the last 7 days, have you purchased bullets and ammunition?"*). Response options for the latter three questions were yes, no, and not sure.

Outcome variables included three perceptions about the COVID-19 pandemic, including: likelihood of civil unrest, importance of taking precautions, and exaggerations of its danger. Respondents were asked how much they agree or disagree with the following statements: *"Coronavirus and the COVID-19 pandemic will probably lead to civil unrest"*; *"It is important to take precautions to avoid potentially infecting other people, even for people who don't have symptoms"*; and *"The threat of coronavirus and COVID-19 has been blown out of proportion"*. We created binary versions of these variables to compare those who agree or strongly agree versus those who indicated that they disagree, strongly disagree, or neither agree nor disagree.

Additional study variables included age category (18-25 years, 26-44 years, or 45+ years), sex (male, female), presence of children younger than 18 years of age in the home, residence in a rural county, whether the respondent was living with a spouse or partner, and race/ethnicity. The race/ethnicity categories were Hispanic/Latino of any race, Non-Hispanic White, Non-Hispanic Black, and "all other," which included respondents who were Asian, American Indian/Alaska Native, Native Hawaiian/Pacific Islander, more than one race, or in another race category. To maximize power, we used binary measures of age (i.e., <45 years vs. ≥45) and race/ethnicity (i.e., Non-Hispanic White vs. all other groups) in final analyses. Rural is specified by matching county of residence to USDA rural-urban continuum classification of counties with less than 2,500 urban population after the 2010 Census.[13]

The data were weighted based on the known population characteristics of the Texas adult population derived from the 2018 Current Population Survey and the 2017 American Community Survey. The sample was balanced to match parameters for sex, age, race/ethnicity, and educational attainment using raking ratio estimation, an iterative proportional fitting method. The use of sample weights in analysis ensures that the characteristics of the sample reflect the characteristics of the Texas population. First, we summarized the sample based on demographic factors, perceptions about the COVID-19-pandemic, and gun ownership. We conducted multiple logistic regression models (with listwise deletion) to assess perceptions in relation to household gun ownership, adjusting for demographic factors. In those models, we used binary measures of perceptions about the COVID-19 pandemic. Analyses were conducted in Stata 14.2.[14]

Given the emerging nature of COVID-19, online samples represent an opportunity to rapidly gather information to inform health promotion and policy development. However, the probability of inclusion in the sample is unknown for online surveys. To address this bias, we conducted additional analyses using methods to further assess the representativeness of estimates.[15] Specifically, to ensure the smaller variance of our estimates are not biased by the parameters of the large nonprobability sample,

we "borrow" information from the nonprobability sample to produce estimates of the probability sample that have more variance. In a sensitivity analysis, we conducted linear regression modeling using Bayesian data integration with responses from the RDD and online samples.[16,17] We retained the 5-level response options for each of the the three variables measuring perceptions about COVID-19 for these analyses. The Bayesian framework is well-suited for integrating multiple data sources of varying quality, such as probability and nonprobability samples. We treated the probability-based RDD sample as having higher quality (i.e., less selection bias) relative to the online sample, an assumption consistent with the survey literature.[18] We constructed informative prior distributions based on data from the online sample to increase the efficiency of the coefficient estimates derived from the smaller RDD sample. We considered four prior specifications that inform the resulting posterior estimates. In this article, we report for the conjugate-difference specification, as it has been shown to have superior properties in simulation studies even in the presence of large selection biases in nonprobability samples and in other real-world applications.[16] We used a linear regression model to estimate the association between having a household gun (versus not) with perceptions about COVID-19. To ensure comparability, linear regression models controlled for the same set of demographic factors used in the logistic regression models described above. The analysis was conducted in R 3.6.0.[19] Additional details on sensitivity analyses as well as results for the other three prior specifications are available online (see Supplemental Materials).

RESULTS

Nearly one-fifth of the respondents were aged 18-25, 37.5% were aged 26-44, and 44.1% were 45 or older (Table 1). Thirty percent had a child in the home, and 46.4% were living with a spouse or partner. The sample was gender-balanced, and 45.3% of respondents were Non-Hispanic White. Forty percent reported having a gun in the household, and 13.9% indicated plans to acquire one in the next two weeks. Respondents who were White or living with a partner were more likely to report a household gun. One-fifth of respondents with a gun in the home were considering getting an additional gun within two weeks, as were 9% of those without a gun in the home.

Among respondents with household guns, 65% had two or more guns and 71.9% indicated personal ownership of a gun (Table 2). When asked about the past 7-days, 15.4% reported a gun purchase, 19.6% reported a purchase of ammunition or bullets, and 25.4% said they carried a gun most or all of the time when away from home. Twenty-eight percent of the respondents who recently purchased a gun had just one household gun.

A large majority (87.9%) agreed that it was important to take precautions to prevent transmission of the virus (Table 3); agreement was high among those with and without guns in the home (89.6% vs. 86.3%). Forty-two percent agreed that COVID-19 would lead to civil unrest and 37.6% agreed that the

pandemic has been "blown out of proportion." Differences in agreement with these statements did not vary substantially by household gun ownership in these bivariate analyses.

Table 4 shows associations between perceptions about COVID-19 and the set of seven binary predictor variables (i.e., household gun, White race, male, partner, children in home, 45+, and rural). Estimates in the first column are from the multiple logistic regression models, and estimates in the second column are from the Bayesian linear regression models that integrated the probability and nonprobability samples. Both sets of models applied Type III sum of squares, i.e., every term in the model is tested in light of every other term in the model.

Although logistic models indicated that those with household guns were 1.38 times more likely to agree that COVID-19 would lead to civil unrest (95% CI: 1.07-1.78), this finding was not observed in the linear regression model, indicating the possibility of sampling bias. Respondents with children were significantly more likely to agree on the possibility of unrest, whereas those aged 45 or older were significantly less likely to. We did not find evidence of an association between having a household gun and agreement on the importance of taking precautions to prevent transmission, although respondents aged 45 or older and with a partner in the home were more likely to agree. (Because of limited variation in responses about perceived importance of taking precautions, we were unable to conduct a sensitivity analysis for this variable.) In the final pair of models, we found that those with a household gun were 1.27 times more likely to agree that the threat of COVID has been "blown out of proportion", although the interval estimate was marginal (95% CI: 0.99-1.63). Men were more likely to agree, whereas respondents aged 45 or older were less likely to agree. Results from the Bayesian linear regression are consistent with the conclusion that people with household guns were more likely to agree the pandemic has been exaggerated; the marginal interval estimate may be due to sample bias or binary coding of the variable.

DISCUSSION

In the US, the COVID-19 pandemic has become intertwined with advocacy for gun rights, leading us to consider that adults with household guns may have different ideas about the pandemic than those without guns. We investigated whether there were differences in perceptions about COVID-19 among Texas adults with versus without guns, and also assessed changes in gun ownership in the early stage of the COVID-19 pandemic in the US. Data collection took place relatively early in the pandemic, before protests against the coronavirus response at the Texas state capitol and prior to the large public protests for racial justice following the death of George Floyd.

Nearly 90% agreed that it was important to take precautions to prevent transmission of the virus, and less than one-half agreed that the pandemic would lead to civil unrest. Surprisingly, results did not offer evidence of differences in the perceived likelihood of civil unrest or the perceived importance of

taking precautions to prevent transmission among those with versus without household guns. It may be that some of the most vocal people out protesting COVID response measures represent a vocal minority of gun owners. Our work suggests that gun owners may be open to public health messaging around ways to prevent the spread of COVID-19. On the other hand, this study does suggest that Texas adults with household guns are more likely to downplay the threat of COVID-19 than those without guns. The polarized discourse about COVID-19 may have led to confusion about the severity of COVID-19, suggesting a need for messaging that offers concrete facts about the effects of COVID-19 on individuals and communities in a manner that does does stir up political identities.[20]

Two-fifths of the respondents in our sample of Texas adults had household guns, a figure consistent with previous estimates for the state.[21,22] Although there has been a secular trend of declining household gun ownership in the past half-century, gun sales in the US have steadily increased over the past 15 years.[11,21] Recent reports demonstrate a substantial spike in gun sales that coincides with the emergence of the COVID-19 pandemic.[23] Our findings offer preliminary evidence that the pandemic may have prompted people to buy or consider buying guns and ammunition.

Nine percent of respondents without household guns in our sample indicated plans to buy one within the next week. Twenty-eight percent of those who had purchased a gun in the prior seven days had just one gun in the home, suggesting they may be first-time gun purchasers. Increases in firearm ownership, particularly during a stressful time for people across the US could pose risks for public health such as intimate partner violence, suicide, and access to unsecured guns by children or teens.

Results of this investigation should be considered in the context of limitations with regard to sampling and generalizability. We used random-digit-dial sampling and non-probability sampling, which allowed us to rapidly gather information about this emerging health issue. Unfortunately, non-probability samples are subject to bias. To address this limitation, we applied innovative strategies for sensitivity analyses to strengthen conclusions.[16,17] Given the rapid pace of the pandemic and changes in mandates and norms about preventive behaviors, findings provide insight in early stage of COVID-19 in the US but cannot be generalized across time. Finally, this sample was drawn from Texas and findings should not be assumed to reflect the US population.

The COVID-19 pandemic continues to devastate the US, and stay-at-home orders have been lifted in every state despite the rapid spread.[1,2] Because effective control of COVID-19 in the US depends on the ability to persuade citizens to comply with public health guidelines, knowledge about COVID-related health beliefs can inform more effective communication strategies.[24-26] People with guns have been portrayed as opposed to COVID-prevention strategies under the guise it is inconsistent with values of freedom and liberty. Consistent with that portrayal, we observed that gun owners in Texas were more likely to think that the threat of COVID-19 has been exaggerated. However, we also observed

modest differences in the perceived importance of taking precautions to prevent COVID among those with versus without household guns. This is positive news that indicates the potential for effective health communication with gun owners about home safety, gun safety, and COVID-prevention, even within our current hyper-partisan social environment.

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Table 1. Respondent and household characteristics, Texas adults (*n* = 1,183)

	Full Sample	Gun in Household		
		Yes	No	Chi-Square (*p*)
Total	100% (1,183)	40.8% (483)	59.2% (700)	---
Age (years)				
18-25	18.3% (217)	15.2% (81)	20.5% (133)	12.65
26-44	37.5% (444)	34.8% (186)	39.5% (255)	(*p*=0.055)
45+	44.1% (522)	50.1% (268)	40.1% (259)	
Race/Ethnicity				
Hispanic/Latino, any race	35.1% (415)	28.3% (152)	39.9% (257)	59.96
Black, Non-Hispanic	11.3% (134)	7.1% (38)	14.3% (92)	(*p*<0.001)
White, Non-Hispanic	45.3% (534)	58.5% (314)	36.1% (233)	
All other	8.3% (98)	6.1% (33)	09.7% (63)	
Sex				
Male	48.6% (575)	52.4% (281)	46.1% (298)	4.77
Female	51.1% (604)	47.3% (253)	53.7% (347)	(*p*=0.220)
Married or living with a partner				25.81
Yes	46.4% (549)	55.3% (296)	40.3% (260)	(*p*<0.001)
No	53.6% (634)	44.7% (240)	59.7% (386)	
Any children in home <18 years				0.19
Yes	30.0% (355)	30.5% (197)	29.3% (157)	(*p*=0.747)
No	70.0% (828)	69.5% (450)	70.7% (379)	
Live in rural area				0.14
Yes	14.1% (166)	14.5% (78)	13.8% (89)	(*p*=0.808)
No	85.9% (1,017)	85.5% (458)	86.2% (558)	
Plan to purchase a gun				34.72
Yes	13.9% (164)	21.0% (111)	9.1% (59)	(*p*<0.001)
No	85.6% (1,011)	79.0% (418)	90.9% (587)	

Note. Values are percentage (n); values may not sum to total due to missing data. Percentages and *n* are weighted to the population of Texas.

Table 2. Number of guns, recent purchases, and gun carrying among people with household guns, Texas (*n*=512)

Characteristic	Prevalence (Confidence Interval)
Two or more household guns	65.2% (59.2%-70.6%)
Respondent is personal owner of a household gun	71.9% (65.9%-77.2%)
At least one member of the household purchased a gun in the past 7 days	15.4% (10.8%-21.5%)
At least one member of the household purchased bullets or ammunition in the past 7 days	19.6% (14.8%-25.6%)
Respondent carried a gun when away from home, all or most of the time, in the past 7 days	25.4% (20.4%-31.1%)

Table 3. Percentage of respondents who agree or strongly agree with statements about COVID-19 and SARS-CoV-2, by household gun ownership

	Total	Gun in Household		
		Yes	No	χ^2 (*p*)
"Coronavirus and the COVID-19 pandemic will probably lead to civil unrest"	42.2%	43.4%	40.2%	1.20 (*p*=0.42)
"It is important to take precautions to avoid potentially infecting other people, even for people who don't have symptoms"	87.9%	89.6%	86.3%	2.72 (*p*=0.28)
"The threat of coronavirus and COVID-19 has been blown out of proportion"	37.6%	39.8%	34.3%	3.66 (*p*=0.17)

Table 4. Association between perceptions about the COVID-19 pandemic among those with (versus without) guns in the household

	Logistic Regression Odds Ratio (95% Confidence Interval)	Linear Regression Coefficient Estimates (95% Credible Interval)
"Coronavirus and the COVID-19 pandemic will probably lead to civil unrest"		
Household gun (vs. none)	**1.38 (1.07, 1.78)**	0.28 (-0.14, 0.71)
White (vs. not)	1.07 (0.78, 1.46)	-0.09 (-0.29, 0.11)
Male (vs. female)	0.80 (0.62, 1.02)	**-0.26 (-0.42, -0.10)**
Live with partner (vs. not)	0.89 (0.68, 1.17)	-0.10 (-0.38, 0.17)
Children in home (vs. not)	**1.39 (1.03, 1.86)**	**0.22 (0.05, 0.40)**
Age ≥45 (vs. <45)	**0.43 (0.32, 0.58)**	-0.40 (-0.80, 0.01)
Rural (vs. not)	1.42 (0.95, 2.11)	**0.23 (0.00, 0.47)**
"It is important to take precautions to avoid potentially infecting other people, even for people who don't have symptoms"*		
Household gun (vs. none)	0.90 (0.57, 1.40)	---
White (vs. not)	0.81 (0.47, 1.39)	---
Male (vs. female)	0.71 (0.45, 1.12)	---
Live with partner (vs. not)	**1.77 (1.06, 2.94)**	---
Children in home (vs. not)	1.00 (0.58, 1.72)	---
Age ≥45 (vs. <45)	**2.27 (1.27, 4.04)**	---
Rural (vs. not)	0.82 (0.45, 1.50)	---
"The threat of coronavirus and COVID-19 has been blown out of proportion"		
Household gun (vs. none)	1.27 (0.99, 1.63)	**0.18 (0.07, 0.29)**
White (vs. not)	0.85 (0.62, 1.16)	0.10 (-0.02, 0.22)
Male (vs. female)	**1.49 (1.15, 1.92)**	**0.42 (0.02, 0.83)**
Live with partner (vs. not)	1.02 (0.78, 1.30)	-0.08 (-0.35, 0.20)
Children in home (vs. not)	1.21 (0.89, 1.64)	0.11 (-0.03, 0.25)
Age ≥45 (vs. <45)	**0.65 (0.49, 0.87)**	**-0.40 (-0.71, -0.08)**
Rural (vs. not)	1.32 (0.91, 1.91)	0.04 (-0.53, 0.60)

* The insufficient variability in the probability data (n=70 after removing missing observations) for this outcome did not allow applying a linear regression model.

Description of the Bayesian Integrated Estimates

The method of integrating probability and nonprobability samples within Bayesian inference for linear regression was used to ensure that results reflected a probability-based sample as much as possible. During the COVID-19 pandemic we needed to conduct a survey in two modes to capture a representative sample: random-digit dial (RDD) telephone and online. The Wiśniowski and Sakshaug method is designed to assist survey researchers who have a small probability sample (e.g. RDD) and want to increase the precision of estimates by integrating survey responses from a non-probability (online) sample of the same population [1,2].

We considered the method of constructing informative prior distributions for the coefficients of the linear regression models based on the non-probability samples as proposed by Wiśniowski and colleagues [1]. The method includes four specifications of the priors:

(i) Conjugate (C), which borrows information from the non-probability sample "proportionally" to its sample size if the maximum likelihood (ML) coefficients from the probability and non-probability samples are similar. If they are not similar, the impact of the non-probability sample is reduced;
(ii) Conjugate Distance (CD), which relates the precision of the prior to the similarity of the ML coefficients from probability and non-probability samples, thus, allowing for larger variability if discrepancies between probability and nonprobability data arise;
(iii) Zellner (Z), which is similar to conjugate but allowing rescaling of the posterior variance for each predictor using information from the non-probability sample;
(iv) Zellner Distance (ZD), which is similar to the Conjugate Distance but again uses information on the non-probability predictors to rescale the posterior variance.

The simulation study by Wiśniowski et al. demonstrated that the Conjugate Distance (CD) specification tends to outperform the others [1]. It was, therefore, selected to be used in the current application. Its robustness is confirmed; results are presented in the Figure below. We observe that this specification typically "strikes a balance" between probability and non-probability coefficients both in terms of point predictions and uncertainty. With the exception of ZD method, the other three specifications lead to qualitatively similar results. The ZD method seems to assign more weight to the probability sample, leading to considerably larger uncertainty. On the other end of the spectrum, the Conjugate prior led to the most precise estimates.

The main limitation of the method is that it relies on two implicit assumptions. First, that we have sufficient response variability in the (small size) probability sample; second, that the estimates based on the non-probability sample are more precise than those based on the small probability sample. As reported in the manuscript, the attitude to "taking precautions" lacked this variability as the vast majority of the respondents agreed with it. Within the probability sample, variability of responses to this question was not found with all 77 telephone respondents indicating it was important to take precautions. This precluded using the Bayesian approach to model this response. However, both assumptions are satisfied in the samples on responses regarding civil unrest and overblown threat of the pandemic. This allows combining information from both small probability and non-probability samples and the results remain reliable.

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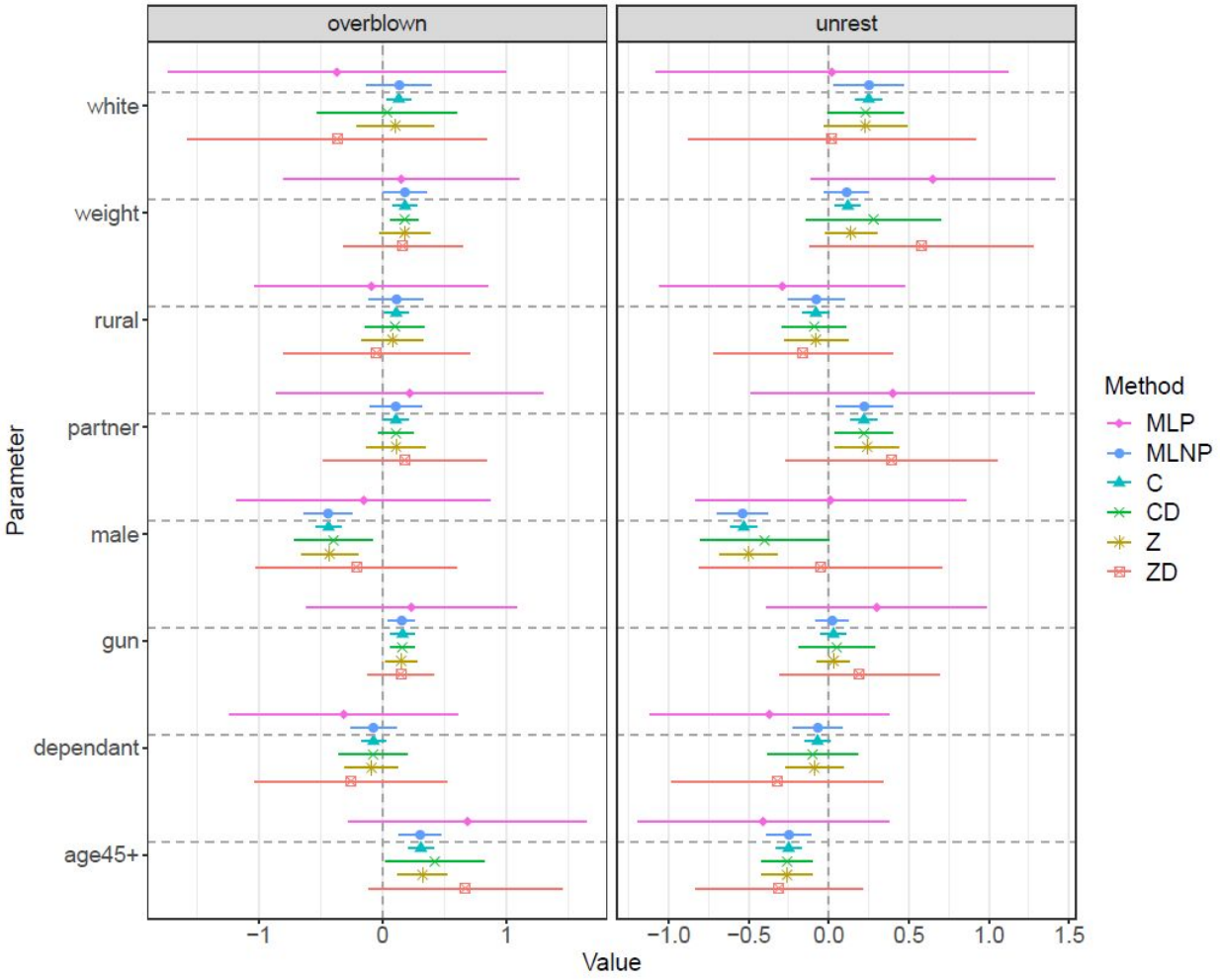

Figure. Coefficients of the linear regression in models for the response stating that the threat of Covid-19 is "overblown" (left panel) and that the pandemic will lead to civil "unrest" (right panel).

Note. MLP = Maximum likelihood on probability (RDD) sample, MLNP = Maximum likelihood on non-probability (online) sample, C = Conjugate, CD = Conjugate-Distance, Z = Zellner, ZD = Zellner-Distance. Figure shows point predictions and 95% interval estimates; including Credible Intervals for C, CD, Z and ZD methods and Confidence Intervals for MLP and MLNP methods.

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Differences in beliefs about COVID-19 by gun ownership: A cross-sectional survey of Texas adults

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DECLARATIONS:

Ethics approval and consent to participate The University of Texas at Tyler Institutional Review Board approved data collection for this study, which is stated in the manuscript.

Consent for publication Not applicable

Patient & public involvement This study did not include patients from any clinical settings. Participants were adult residents on Texas.

Availability of data and materials The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests The authors declare that they have no competing interests.

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Authors' contributions RM Johnson and M Owens conceived of the paper and developed survey items. M Owens secured funding and conducted data collection. RM Johnson, M Owens, and EMA Goodell worked together to plan and conduct data analysis. A Wisniowski and JW Sakshaug conducted sensitivity analyses. C Crifasi, M Owens, and RM Johnson drafted the full manuscript, with substantive input from all authors.

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ABSTRACT

Objectives. We investigated the association between gun ownership and perceptions about COVID-19 among Texas adults as the pandemic emerged. We considered perceived likelihood that the pandemic would lead to civil unrest, perceived importance of taking precautions to prevent transmission, and perceptions that the threat of COVID-19 has been exaggerated.

Methods. Data were collected April 5th through 12th in 2020, shortly after Texas's stay-at-home declaration. We generated a sample using random-digit-dial methods for a telephone survey (n=77, response rate=8%) and by randomly selecting adults from an ongoing panel to complete the survey online (n=1,120, non-probability sample). We conducted logistic regression to estimate differences in perceptions by gun ownership. To account for bias associated with use of a non-probability sample, we used Bayesian data integration and ran linear regression models to produce more accurate measures of association.

Results. Among the 60% of Texas adults who reported gun ownership, estimates of past 7-day gun purchases, ammunition purchases, and gun carrying were 15% (*n*=78), 20% (*n*=100), and 24% (*n*=130), respectively. We found no evidence of an association between gun ownership with perceived importance of taking precautions to prevent transmission or with perceived likelihood of civil unrest. Results from the logistic regression (OR: 1.27, 95% CI: 0.99, 1.63) and the linear regression (β=0.18, 95% CI: 0.07, 0.29) suggest that gun owners may be more likely to believe the threat of COVID-19 was exaggerated.

Conclusions. Compared to those without guns, gun owners may have been inclined to downplay the threat of COVID-19 early in the pandemic.

Abstract Word Count: 250

Strengths and limitations of this study

- We used a mixed-mode approach to sampling Texas adults that included random-digit-dial sampling and non-probability sampling from an ongoing panel of Texas adults.
- Use of non-probability sampling methods allowed us to rapidly gauge how Texas adults' perceptions about the COVID-19 pandemic differed by gun ownership.
- The probability sample had a low response rate (8%), increasing the likelihood of misestimation of associations because of sampling error.
- The mixed-mode sampling design enabled us to use information from the probability sample in a sensitivity analysis. We conducted Bayesian data integration to generate more accurate estimates of association.
- Findings cannot be generalized beyond the state of Texas.

INTRODUCTION

In the US, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) first occurred in Washington State in March 2020. COVID-19, the disease caused by SARS-CoV-2, has since emerged as a public health catastrophe with more than a half-million deaths in the US.[1] Given the highly-infectious nature of SARS-CoV-2, states began to enact stay-at-home orders to slow the spread in mid-March.[2] The public health response quickly became enmeshed in 'culture wars,' with groups staging protests in opposition to those orders.[3] Protesters expressed their view that COVID-19 was not a serious disease, no worse than the flu, and characterized stay-at-home orders and other measures to prevent transmission (e.g., closures of schools and restaurants) as federal overreach and a threat to freedom and liberty. News and social media have given the impression that there was substantial overlap in groups demonstrating against stay-at-home orders and those supporting individualistic interpretations of the Second Amendment. Some protestors openly carried firearms at demonstrations, further suggesting links between those who favor unrestricted rights to have and carry guns and those who oppose public health measures to control COVID-19.[4]

In this study, we sought to explore the overlap in perceptions about COVID-19 and gun ownership in Texas, a state where there was strong opposition to stay-at-home orders.[5,6] Texas has the second-largest population size of all US states, and it is a conservative-leaning state with a culture supportive of gun ownership and a history of independence from the federal government. The state established a stay-at-home order in April 2020, after many states across the US and nearly one-third of counties in Texas had already done so.[2,5] Shortly thereafter, there were protests at the Texas State Capitol with demands for reopening businesses and schools, and calls for "freedom from tyranny".[6,7]

Connections between support for individualistic interpretations of the Second Amendment and opposition to the public health response to COVID-19 may have roots in politics and industry practices. The National Rifle Association (NRA) and the firearm industry more broadly capitalized on fear and uncertainty around COVID-19 to promote guns as necessary during the pandemic;[8] these efforts may have ramped up beliefs that there would be civil unrest. After several states classified gun dealers as non-essential businesses, the President of the United States ordered the firearm industry be classified as essential at the federal level, forcing states that had closed gun shops to allow them to operate.[9] This action bolstered support for the President and others in his political party from gun rights activists in an election year. There were dramatic increases in firearm sales as the COVID-19 pandemic emerged.[10] The number of monthly background checks conducted by the Federal Bureau of Investigation (FBI) is an indicator of gun purchases; the number of monthly background checks in June 2020 was 70% higher than in June 2019.[11]

In the US, and in Texas specifically, the COVID-19 pandemic was highly-politicized and became intertwined with conservative political ideologies, including ideas around individual gun rights. There are many potential adverse outcomes related to politicizing the COVID-19 pandemic; people may downplay the severity of the disease and become less willing to take the recommend public health precautions or support public health mandates, people may buy guns and ammunition, and people may be more inclined to carry their guns around. Failure to take recommended precautions could lead to increased spread of SARS-CoV-2, whereas gun acquisitions and increased gun carrying may increase risk for firearm suicide, lethal assaults, and unintentional injuries.[10] Apparent connections between beliefs about gun rights and about perceptions of COVID-19 raises the possibility that people with guns may be less supportive of

public health strategies to respond to the pandemic. To enhance what is known on this topic, we investigate: (1) differences in perceptions about COVID-19 among Texas adults with versus without guns, and (2) recent gun acquisitions, gun carrying, and purchases of ammunition among those with guns. We explore perceptions that the COVID-19 pandemic will lead to civil unrest, perceived importance of taking precautions to prevent transmission, and perceptions that the threat of COVID-19 has been exaggerated.

METHODS

Data for this cross-sectional study come from the Texas Mental Health Survey, which was a statewide sample of adult residents conducted from April 5-12, 2020. The Institutional Review Board at University of Texas at Tyler approved data collection, and participants had no involvement in the planning or conduct of the study. Data collection began shortly after the statewide stay-at-home order went into effect. SARS-CoV-2 infections and COVID-19 deaths in the state nearly doubled over the data collection period; reported infections increased from 7,276 to 14,624, and fatalities increased from 140 to 318.[1,2] Eligible respondents were Texas residents, fluent in English or Spanish, and age 18 or older. The mixed-mode sample included 77 residents who were contacted by telephone using random-digit-dial (RDD) sampling and 1,120 residents who were randomly selected from a panel of adults in the state who opted-in to take online surveys through Dynata, a survey research company. Members of the Dynata panel conducted an informed consent process upon enrolling in the panel. For respondents in the RDD sample, interviewers conducted informed consent prior to beginning the survey. The online and telephone surveys were conducted in both English and Spanish. The response rate for RDD

sample was 8%. [12] We restricted analysis to the 1,183 respondents who answered the item about household guns.

The main exposure variable was household gun ownership, assessed with the following question: "*Do you happen to have any guns or revolvers in your home, garage, or car?*". All respondents were asked about plans to acquire guns: "*Are you or is anyone in your household considering getting a gun for your home in the next 2 weeks?*". Respondents with a household gun were asked about: [a] the number of guns (i.e., "*How many guns are there in your home, garage, or car?*"; options were 1, 2, 3+, and 'not sure'); [b] personal gun ownership ("*Do any of the guns belong to you, personally?*"); [c] recent gun acquisitions ("*Were any of the guns in your home purchased or obtained within the last 7 days?*"); and [d] recent ammunition purchases ("*In the last 7 days, have you purchased bullets and ammunition?"*). Response options for the latter three questions were yes, no, and not sure.

Outcome variables included three perceptions about the COVID-19 pandemic, including: likelihood of civil unrest, importance of taking precautions, and exaggerations of its danger. Respondents were asked how much they agree or disagree with the following statements: *"Coronavirus and the COVID-19 pandemic will probably lead to civil unrest"*; *"It is important to take precautions to avoid potentially infecting other people, even for people who don't have symptoms"*; and *"The threat of coronavirus and COVID-19 has been blown out of proportion"*. We created binary versions of these variables to compare those who agree or strongly agree versus those who indicated that they disagree, strongly disagree, or neither agree nor disagree.

Additional study variables included age category (18-25 years, 26-44 years, or 45+ years), sex (male, female), presence of children younger than 18 years of age in the home, residence in a rural county, whether the respondent was living with a spouse or partner, and

race/ethnicity. The race/ethnicity categories were Hispanic/Latino of any race, non-Hispanic White, non-Hispanic Black, and "all other," which included respondents who were Asian, American Indian/Alaska Native, Native Hawaiian/Pacific Islander, more than one race, or in another race category. To maximize power, we used binary measures of age (i.e., <45 years vs. ≥45) and race/ethnicity (i.e., non-Hispanic White vs. all other groups) in final analyses. Rural is specified by matching county of residence to USDA rural-urban continuum codes; rural counties were those with an urban population of less than 2,500 as of the 2010 Census.[13]

To adjust for nonresponse and noncoverage, the data were weighted based on the known population characteristics of the Texas adult population derived from the 2018 Current Population Survey and the 2017 American Community Survey. The sample was balanced to match parameters for sex, age, race/ethnicity, and educational attainment using raking ratio estimation, an iterative proportional fitting method. The use of sample weights in analysis ensures that the characteristics of the sample reflect the characteristics of the Texas population. First, we summarized the sample based on demographic factors, perceptions about the COVID-19-pandemic, and gun ownership. Then we conducted multiple logistic regression models (with listwise deletion) to assess perceptions in relation to household gun ownership, adjusting for demographic factors. In those models, we used binary measures of perceptions about the COVID-19 pandemic. Analyses were conducted in Stata 14.2.[14]

Given the emerging nature of COVID-19, online samples represent an opportunity to rapidly gather information to inform health promotion and policy development. However, the probability of inclusion in the sample is unknown for online surveys. To address this bias, we conducted additional analyses to further assess the representativeness of estimates.[15] Specifically, to ensure the smaller variance of our estimates are not biased by the parameters of

the large nonprobability sample, we "borrow" information from the nonprobability sample to produce estimates of the probability sample that have more variance. In a sensitivity analysis, we conducted linear regression modeling using Bayesian data integration with responses from the RDD and online samples.[16,17] We retained the 5-level response options for each of the the three variables measuring perceptions about COVID-19 for these analyses. The Bayesian framework is well-suited for integrating multiple data sources of varying quality, such as probability and nonprobability samples. We treated the probability-based RDD sample as having higher quality (i.e., less selection bias) relative to the online sample, an assumption consistent with the survey literature.[18] We constructed informative prior distributions based on data from the online sample to increase the efficiency of the coefficient estimates derived from the smaller RDD sample. We considered four prior specifications that inform the resulting posterior estimates. In this article, we report conjugate-difference specification, as it has been shown to have superior properties in simulation studies even in the presence of large selection biases in nonprobability samples and in other real-world applications.[16] We used a linear regression model to estimate the association between having a household gun (versus not) with perceptions about COVID-19. To ensure comparability, linear regression models controlled for the same set of demographic factors used in the logistic regression models described above. The analysis was conducted in R 3.6.0.[19] Additional details on sensitivity analyses as well as results for the other three prior specifications are available online (see Supplemental Material).

RESULTS

There were 1,183 respondents in the sample, and 40.8% reported having a household gun (Table 1). Nearly one-fifth of the respondents were aged 18-25, 37.5% were aged 26-44, and

44.1% were 45 or older. Thirty percent had a child in the home, and 46.4% were living with a spouse or partner. The sample was sex-balanced, and 45.3% of respondents were non-Hispanic White. Respondents who were White or who were living with a partner were more likely to report a household gun. Thirteen percent of the respondents indicated plans to acquire a gun in the next two weeks, two-thirds of that group indicated there was already a gun in the home (111 out of 164).

Among the 483 respondents with household guns, 65% had two or more guns (*n*=315) and 71.9% (*n*=348) indicated personal ownership of a gun (Table 2). When asked about the past 7 days, 15.4% reported a gun purchase (*n*=74), 19.6% reported a purchase of ammunition or bullets (*n*=95), and 25.4% said they carried a gun most or all of the time when away from home (*n*=123). Twenty-eight percent of the respondents who reported a past 7-day gun purchase indicated there was just one gun in their household.

A large majority (87.9%) agreed that it was important to take precautions to prevent transmission of the virus (Table 3); agreement was high among those with and without guns in the home (89.6% vs. 86.3%). Forty-two percent agreed that COVID-19 would lead to civil unrest and 37.6% agreed that the pandemic has been "blown out of proportion." Differences in agreement with these statements did not vary substantially by household gun ownership in bivariate analyses.

Table 4 shows associations between perceptions about COVID-19 and the set of seven binary predictor variables (i.e., household gun, White race, male, partner, children in home, 45+, and rural). Estimates in the first column are from the logistic regression models, and estimates in the second column are from the Bayesian linear regression models that integrated the probability

and nonprobability samples. Both sets of models applied Type III sum of squares, i.e., every term in the model is tested in light of every other term in the model.

Analyses do not provide evidence of an association between gun ownership with perceived likelihood of civil unrest or with perceived importance of taking precautions. Although logistic models indicated that those with household guns were 1.38 times more likely to agree that COVID-19 would lead to civil unrest (95% CI: 1.07-1.78), this finding was not observed in the linear regression model, indicating the possibility of sampling bias. Respondents with children were significantly more likely to agree on the possibility of unrest, whereas those aged 45 or older were significantly less likely to. The logistic regression model did not indicate an association between having a household gun and agreement on the importance of taking precautions to prevent transmission, although respondents aged 45 or older and with a partner in the home were more likely to agree. (Because of limited variation in responses about perceived importance of taking precautions, we were unable to conduct a sensitivity analysis for this variable.)

In the final pair of models, the logistic regression model showed that those with a household gun were 1.27 times more likely to agree that the threat of COVID has been "blown out of proportion," although the interval estimate included the null (95% CI: 0.99-1.63). Men were more likely to agree, whereas respondents aged 45 or older were less likely to agree. Results from the Bayesian linear regression are consistent with the conclusion that people with household guns were more likely to agree the pandemic has been exaggerated. The parameter estimate of 0.18 was statistically significant, with a 95% credible interval of 0.07-0.29. Thus, the evidence suggests that there is a modest association between perceptions that the pandemic has

been overblown and gun ownership, with gun owners being more likely to agree that it has been overblown.

DISCUSSION

In the US, the COVID-19 pandemic has become intertwined with advocacy for gun rights, leading us to consider that adults with household guns may have different ideas about the pandemic than those without guns. We investigated whether there were differences in perceptions about COVID-19 among Texas adults with versus without guns, and also assessed changes in gun ownership in the early stage of the COVID-19 pandemic in the US. Data collection took place relatively early in the pandemic, before protests against the coronavirus response at the Texas state capitol and prior to the large public protests for racial justice following the death of George Floyd.

Nearly 90% agreed that it was important to take precautions to prevent transmission of the virus, and less than one-half agreed that the pandemic would lead to civil unrest. Surprisingly, results did not offer evidence of differences in the perceived likelihood of civil unrest or the perceived importance of taking precautions to prevent transmission among those with versus without household guns. It may be that some of the most vocal people out protesting COVID response measures represent a minority of gun owners. Our work suggests that gun owners may be open to public health messaging around ways to prevent the spread of COVID-19. On the other hand, this study offers evidence that Texas adults with household guns may be slightly more likely to downplay the threat of COVID-19 than those without guns. The polarized discourse about COVID-19 may have led to confusion about the severity of COVID-19,

suggesting a need for messaging that offers concrete facts about the effects of COVID-19 on individuals and communities in a manner that does does stir up political identities.[20]

Two-fifths of the respondents in our sample of Texas adults had household guns, a figure consistent with previous estimates for the state.[21,22] Although there has been a secular trend of declining household gun ownership in the past half-century, gun sales in the US have steadily increased over the past 15 years.[11,21] Recent reports demonstrate a substantial spike in gun sales that coincides with the emergence of the COVID-19 pandemic.[23] Our findings offer preliminary evidence that the pandemic may have prompted people to buy or consider buying guns and ammunition. Among those with guns, 15% reported a past 7-day gun purchase and nearly one-fifth reported a recent ammunition purchase. Twenty-eight percent of respondents who had purchased a gun in the prior seven days had only a single gun in their home, suggesting they may have been first-time gun purchasers. Of those without household guns, 9% indicated plans to buy one within the next week. Increases in firearm ownership, particularly during a stressful time for people across the US could pose risks for public health such as intimate partner violence, suicide, and access to unsecured guns by children or teens.

Results of this investigation should be considered in the context of limitations with regard to sampling and generalizability. This sample was drawn from Texas and findings should not be assumed to reflect the US population. We used random-digit-dial sampling and non-probability sampling, which allowed us to rapidly gather information about this emerging health issue. However, both modes of samples are subject to bias. As with most general population survey efforts these days, we had a low response rate for the probability sample, which increases the likelihood of nonresponse error. We do not have information about those who did not participate, although the literature suggest that they are likely to be younger than survey respondents. Older

adults are more likely to have household guns, but are also more inclined to believe that COVID-19 is a serious illness and that precautions should be taken. It is therefore likely that our results are conservatively biased, i.e., biased toward the null. To address the limitations of non-probability sampling, we applied innovative strategies for sensitivity analyses to strengthen conclusions.[16,17] Additionally, we adjusted for nonresponse in both samples by using sample weights based on several socio-demographic characteristics (i.e., sex, race/ethnicity, age, and educational attainment), a standard procedure for addressing nonresponse in surveys.

Given the rapid pace of the pandemic and changes in mandates and norms about preventive behaviors, findings provide insight in early stage of COVID-19 in the US but cannot be generalized beyond that period. Unfortunately, the COVID-19 pandemic continues to devastate the US and Texas despite the availability of a vaccine.[1,2] Because effective control of COVID-19 in the US depends on the ability to persuade citizens to comply with public health guidelines, knowledge about COVID-related health beliefs can inform more effective communication strategies.[24-26] People with guns have been portrayed as opposed to COVID-prevention strategies under the guise it is inconsistent with values of freedom and liberty. Consistent with that portrayal, our findings suggest that gun owners in Texas were more likely to think that the threat of COVID-19 has been exaggerated. However, we did not observe differences in the perceived importance of taking precautions to prevent COVID among those with versus without household guns. This is positive news that indicates the potential for effective health communication with gun owners about home safety, gun safety, and COVID-prevention, even within the US's hyper-partisan social environment.

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Table 1. Respondent and household characteristics, Texas adults (n = 1,183)

	Full Sample (n=1,183)	Gun in Household		
		Yes (40.8% n=483)	No (59.2%, n=700)	Chi-Square (p)
Age (years)				
18-25	18.3% (217)	15.2% (81)	20.5% (133)	12.65
26-44	37.5% (444)	34.8% (186)	39.5% (255)	(p=0.055)
45+	44.1% (522)	50.1% (268)	40.1% (259)	
Race/Ethnicity				
Hispanic/Latino, any race	35.1% (415)	28.3% (152)	39.9% (257)	59.96
Black, Non-Hispanic	11.3% (134)	7.1% (38)	14.3% (92)	(p<0.001)
White, Non-Hispanic	45.3% (534)	58.5% (314)	36.1% (233)	
All other	8.3% (98)	6.1% (33)	09.7% (63)	
Sex				
Male	48.6% (575)	52.4% (281)	46.1% (298)	4.77
Female	51.1% (604)	47.3% (253)	53.7% (347)	(p=0.220)
Married or living with a partner				25.81
Yes	46.4% (549)	55.3% (296)	40.3% (260)	(p<0.001)
No	53.6% (634)	44.7% (240)	59.7% (386)	
Any children in home <18 years				
Yes	30.0% (355)	30.5% (197)	29.3% (157)	0.19
No	70.0% (828)	69.5% (450)	70.7% (379)	(p=0.747)
Live in rural area				
Yes	14.1% (166)	14.5% (78)	13.8% (89)	0.14
No	85.9% (1,017)	85.5% (458)	86.2% (558)	(p=0.808)
Plan to purchase a gun				
Yes	13.9% (164)	21.0% (111)	9.1% (59)	34.72
No	85.6% (1,011)	79.0% (418)	90.9% (587)	(p<0.001)

Note. Values are weighted percentage (unweighted n); values may not sum to total due to missing data. Percentages sum to 100% by column, except for the header row (i.e., percentage with and without household guns), which sums to 100% by row. Respondents in the "all other" race/ethnicity group were Asian, American Indian/Alaska Native, Native Hawaiian/Pacific Islander, more than one race, or were not in any of the race groups listed on the survey.

Table 2. Prevalence estimates (95% confidence interval) for number of guns, recent purchases, and gun carrying among people with household guns, Texas (*unweighted n*=483)

Characteristic	Prevalence (95% CI)
Two or more household guns	65.2% (59.2%-70.6%)
Respondent is personal owner of a household gun	71.9% (65.9%-77.2%)
At least one member of the household purchased a gun in the past 7 days	15.4% (10.8%-21.5%)
At least one member of the household purchased bullets or ammunition in the past 7 days	19.6% (14.8%-25.6%)
Respondent carried a gun when away from home, all or most of the time, in the past 7 days	25.4% (20.4%-31.1%)

Note. Prevalence estimates and confidence intervals (CI) are weighted.

Table 3. Percentage of respondents who agree or strongly agree with statements about COVID-19 and SARS-CoV-2, by household gun ownership (*n*=1,183)

	Total	Gun in Household		
	(*n*=1,183)	Yes (*n*=483)	No (*n*=700)	χ^2 (*p*)
"Coronavirus and the COVID-19 pandemic will probably lead to civil unrest"	42.2% (499)	43.4% (210)	40.2% (280)	1.20 (*p*=0.42)
"It is important to take precautions to avoid potentially infecting other people, even for people who don't have symptoms"	87.9% (1,039)	89.6% (433)	86.3% (604)	2.72 (*p*=0.28)
"The threat of coronavirus and COVID-19 has been blown out of proportion"	37.6% (444)	39.8% (192)	34.3% (240)	3.66 (*p*=0.17)

Note. Reported numbers of subjects (*n*) are unweighted.

Table 4. Association between perceptions about the COVID-19 pandemic among those with (versus without) guns in the household

	Logistic Regression Odds Ratio (95% Confidence Interval)	Linear Regression Coefficient Estimates (95% Credible Interval)
"Coronavirus and the COVID-19 pandemic will probably lead to civil unrest"		
Household gun (vs. none)	**1.38 (1.07, 1.78)**	0.28 (-0.14, 0.71)
White (vs. not)	1.07 (0.78, 1.46)	-0.09 (-0.29, 0.11)
Male (vs. female)	0.80 (0.62, 1.02)	**-0.26 (-0.42, -0.10)**
Live with partner (vs. not)	0.89 (0.68, 1.17)	-0.10 (-0.38, 0.17)
Children in home (vs. not)	**1.39 (1.03, 1.86)**	**0.22 (0.05, 0.40)**
Age ≥45 (vs. <45)	**0.43 (0.32, 0.58)**	-0.40 (-0.80, 0.01)
Rural (vs. not)	1.42 (0.95, 2.11)	**0.23 (0.00, 0.47)**
"It is important to take precautions to avoid potentially infecting other people, even for people who don't have symptoms"*		
Household gun (vs. none)	0.90 (0.57, 1.40)	---
White (vs. not)	0.81 (0.47, 1.39)	---
Male (vs. female)	0.71 (0.45, 1.12)	---
Live with partner (vs. not)	**1.77 (1.06, 2.94)**	---
Children in home (vs. not)	1.00 (0.58, 1.72)	---
Age ≥45 (vs. <45)	**2.27 (1.27, 4.04)**	---
Rural (vs. not)	0.82 (0.45, 1.50)	---
"The threat of coronavirus and COVID-19 has been blown out of proportion"		
Household gun (vs. none)	1.27 (0.99, 1.63)	**0.18 (0.07, 0.29)**
White (vs. not)	0.85 (0.62, 1.16)	0.10 (-0.02, 0.22)
Male (vs. female)	**1.49 (1.15, 1.92)**	**0.42 (0.02, 0.83)**
Live with partner (vs. not)	1.02 (0.78, 1.30)	-0.08 (-0.35, 0.20)
Children in home (vs. not)	1.21 (0.89, 1.64)	0.11 (-0.03, 0.25)
Age ≥45 (vs. <45)	**0.65 (0.49, 0.87)**	**-0.40 (-0.71, -0.08)**
Rural (vs. not)	1.32 (0.91, 1.91)	0.04 (-0.53, 0.60)

* Insufficient variability in responses did not allow applying a linear regression model.

Description of the Bayesian Integrated Estimates

The method of integrating probability and nonprobability samples within Bayesian inference for linear regression was used to ensure that results reflected a probability-based sample as much as possible. During the COVID-19 pandemic we needed to conduct a survey in two modes to capture a representative sample: random-digit dial (RDD) telephone and online. The Wiśniowski and Sakshaug method is designed to assist survey researchers who have a small probability sample (e.g. RDD) and want to increase the precision of estimates by integrating survey responses from a non-probability (online) sample of the same population [1,2].

We considered the method of constructing informative prior distributions for the coefficients of the linear regression models based on the non-probability samples as proposed by Wiśniowski and colleagues [1]. The method includes four specifications of the priors:

(i) Conjugate (C), which borrows information from the non-probability sample "proportionally" to its sample size if the maximum likelihood (ML) coefficients from the probability and non-probability samples are similar. If they are not similar, the impact of the non-probability sample is reduced;
(ii) Conjugate Distance (CD), which relates the precision of the prior to the similarity of the ML coefficients from probability and non-probability samples, thus, allowing for larger variability if discrepancies between probability and nonprobability data arise;
(iii) Zellner (Z), which is similar to conjugate but allowing rescaling of the posterior variance for each predictor using information from the non-probability sample;
(iv) Zellner Distance (ZD), which is similar to the Conjugate Distance but again uses information on the non-probability predictors to rescale the posterior variance.

The simulation study by Wiśniowski et al. demonstrated that the Conjugate Distance (CD) specification tends to outperform the others [1]. It was, therefore, selected to be used in the current application. Its robustness is confirmed; results are presented in the Figure below. We observe that this specification typically "strikes a balance" between probability and non-probability coefficients both in terms of point predictions and uncertainty. With the exception of ZD method, the other three specifications lead to qualitatively similar results. The ZD method seems to assign more weight to the probability sample, leading to considerably larger uncertainty. On the other end of the spectrum, the Conjugate prior led to the most precise estimates.

The main limitation of the method is that it relies on two implicit assumptions. First, that we have sufficient response variability in the (small size) probability sample; second, that the estimates based on the non-probability sample are more precise than those based on the small probability sample. As reported in the manuscript, the attitude to "taking precautions" lacked this variability as the vast majority of the respondents agreed with it. Within the probability sample, variability of responses to this question was not found with all 77 telephone respondents indicating it was important to take precautions. This precluded using the Bayesian approach to model this response. However, both assumptions are satisfied in the samples on responses regarding civil unrest and overblown threat of the pandemic. This allows combining information from both small probability and non-probability samples and the results remain reliable.

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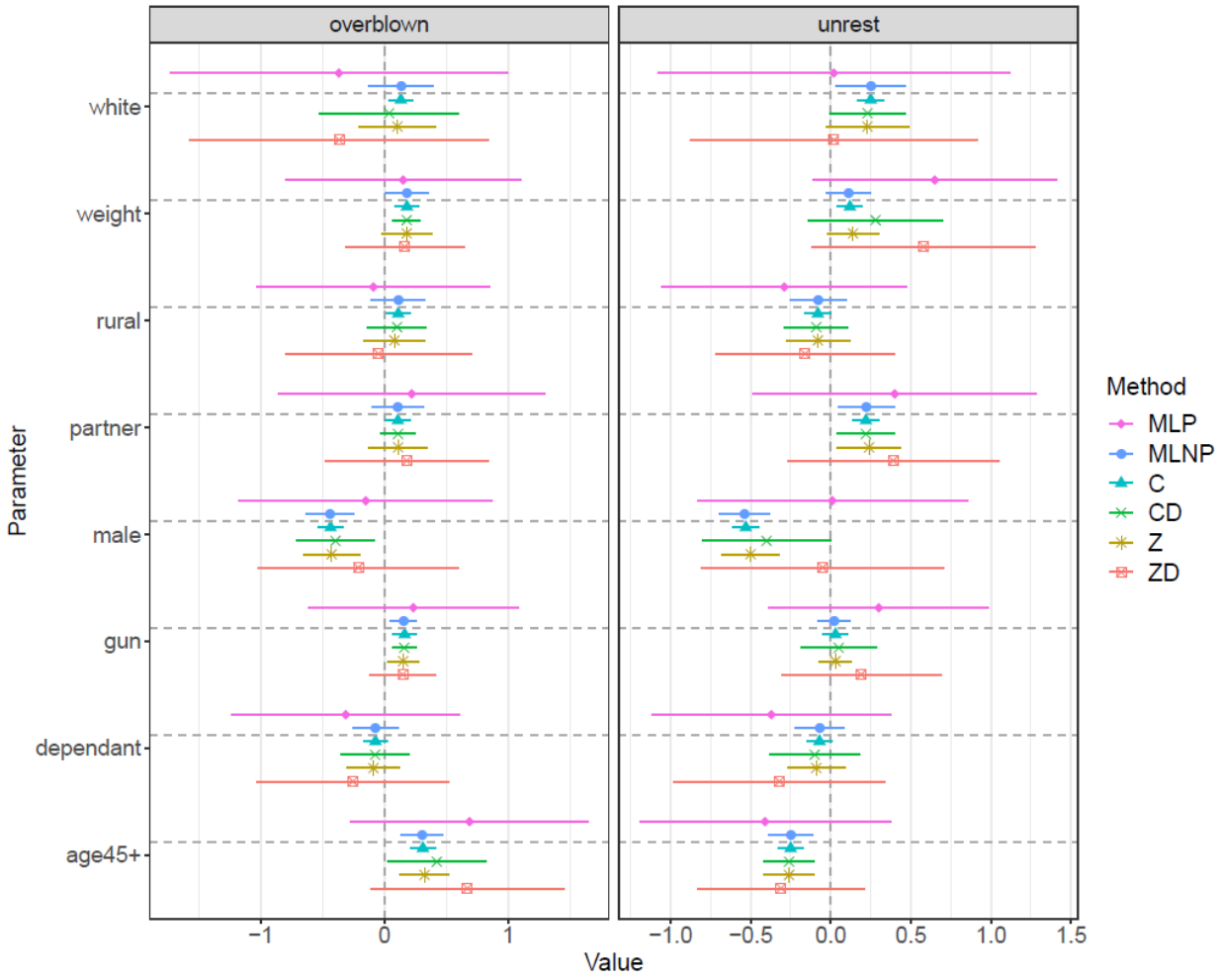

Figure. Coefficients of the linear regression in models for the response stating that the threat of Covid-19 is "overblown" (left panel) and that the pandemic will lead to civil "unrest" (right panel).

Note. MLP = Maximum likelihood on probability (RDD) sample, MLNP = Maximum likelihood on non-probability (online) sample, C = Conjugate, CD = Conjugate-Distance, Z = Zellner, ZD = Zellner-Distance. Figure shows point predictions and 95% interval estimates; including Credible Intervals for C, CD, Z and ZD methods and Confidence Intervals for MLP and MLNP methods.